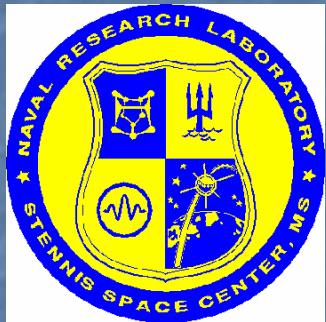


An Overview of Nested Regions Using HYCOM



**Patrick Hogan
Alan Wallcraft
Luis Zamudio
Sergio DeRada
Prasad Thoppil**

Naval Research Laboratory
Stennis Space Center, MS

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Report Documentation Page

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Outline

- Motivation

- Open boundary nesting techniques

- Different nested regions

East Asian Seas region – *shallow isopycnals*

Japan/East Sea – *Intrathermocline Eddies*

Gulf of California – *sensitivity to BC params*

Gulf of Mexico – *cross-shelf exchange*

California Current System – *HYCOM-NCOM coupling*

Norwegian Coastal Current – *buoyancy driven current*

Persian Gulf – *contaminant dispersion*

- Need generic and accurate horizontal and vertical interpolation

- Need to cover wide range of flow regimes

Navy Ocean Circulation Prediction

Expected Evolution

OPERATIONAL

Through FY07

FY 08 & Beyond

Naval
Global
Ocean
Prediction

1/32°NLOM, 1/8°NCOM

HYCOM
(Hybrid
Coordinate
Ocean Model)

Boundary Conditions

Navy
Coastal
Ocean
Prediction

SWAFS, Relocatable NCOM, associated
updates

HYCOM
ADCIRC
NCOM



Note: Coastal component does not include nearshore environment

Current Status of Nesting

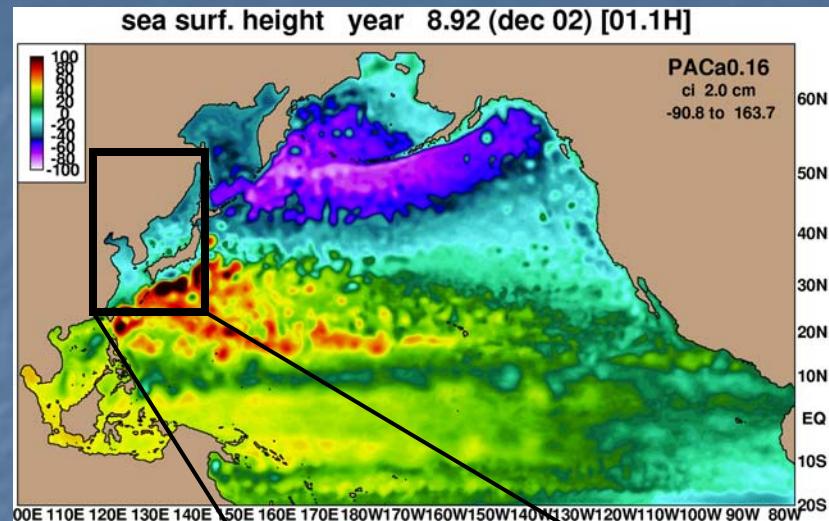
HYCOM NESTING in HYCOM

- Currently off-line
- Boundary info comes from archive files
- Exact boundary condition for depth averaged (barotropic) component
- Relaxation in buffer zone for T,S,P,u,v

Off-line:

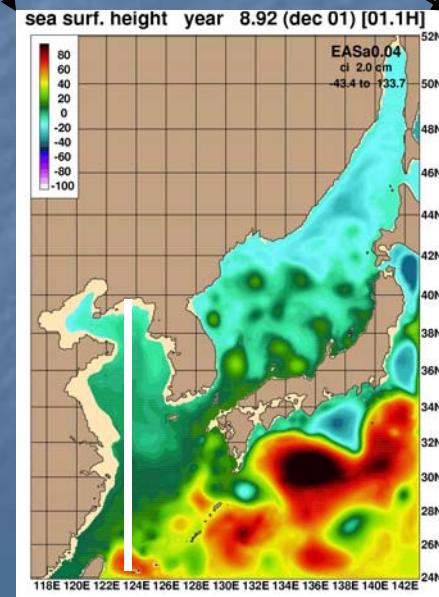
- Boundary information comes from archive files
- Updating frequency limited by archive file frequency
- Don't need to know nest area in advance

3.5 km East Asian Seas HYCOM
Nested inside 16 km North Pacific HYCOM



open boundary
conditions from 1/6°
North Pacific HYCOM

Same vertical structure
as Pacific Ocean model
(20 layers)

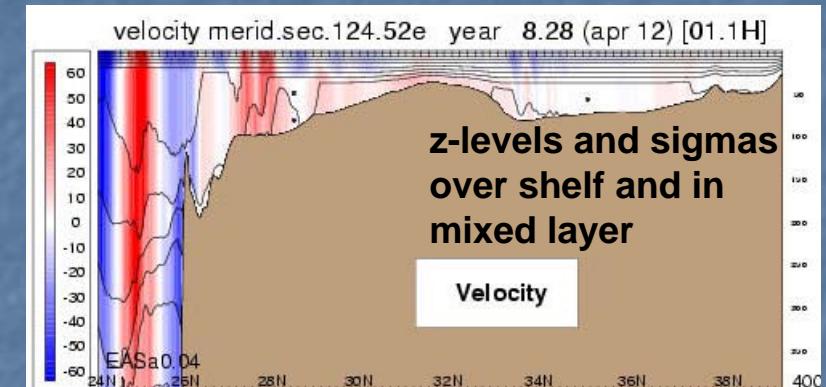
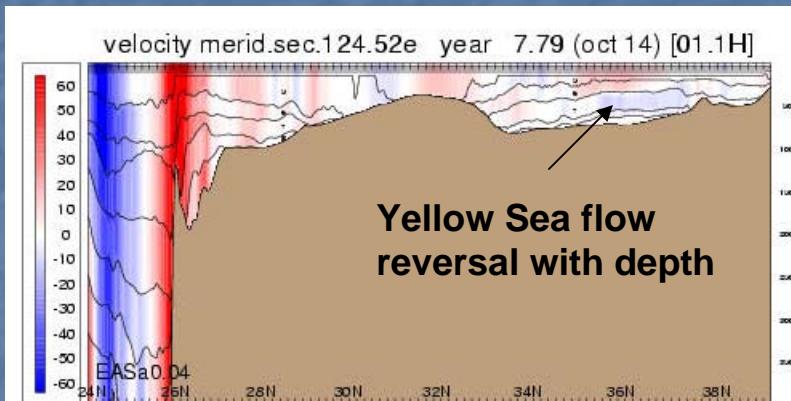




1/25° HYCOM East Asian Seas Model (nested inside 1/6° North Pacific Model)

blue=westward flow
red=eastward flow

North-south cross-section along 124.5°E

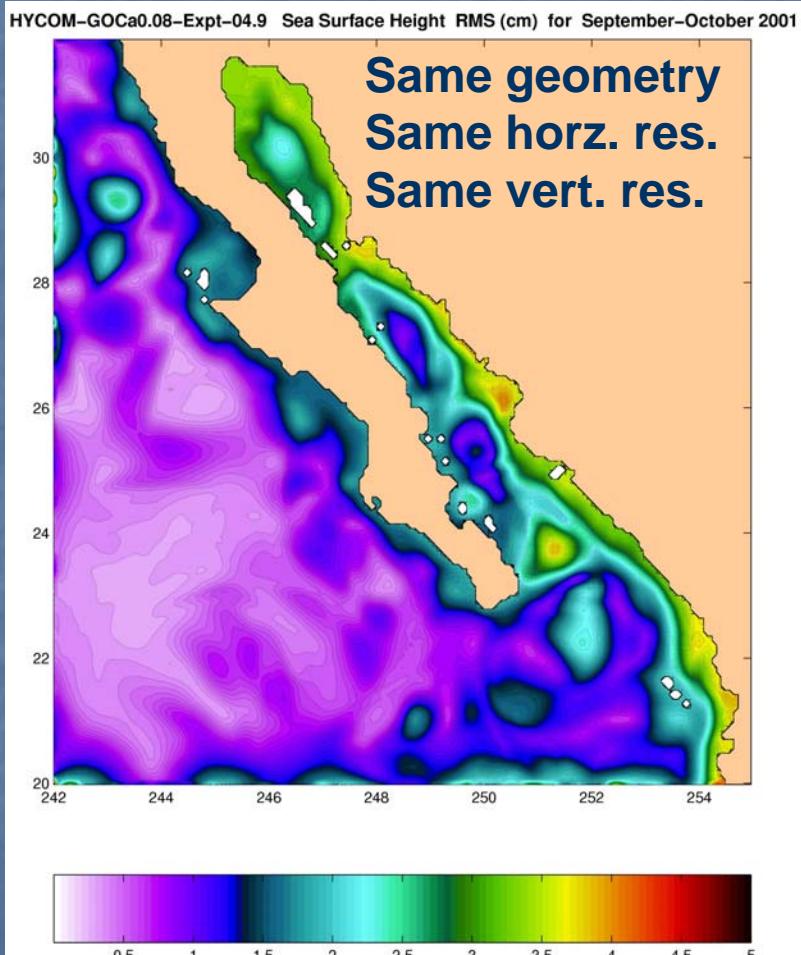


Snapshot on Oct. 14

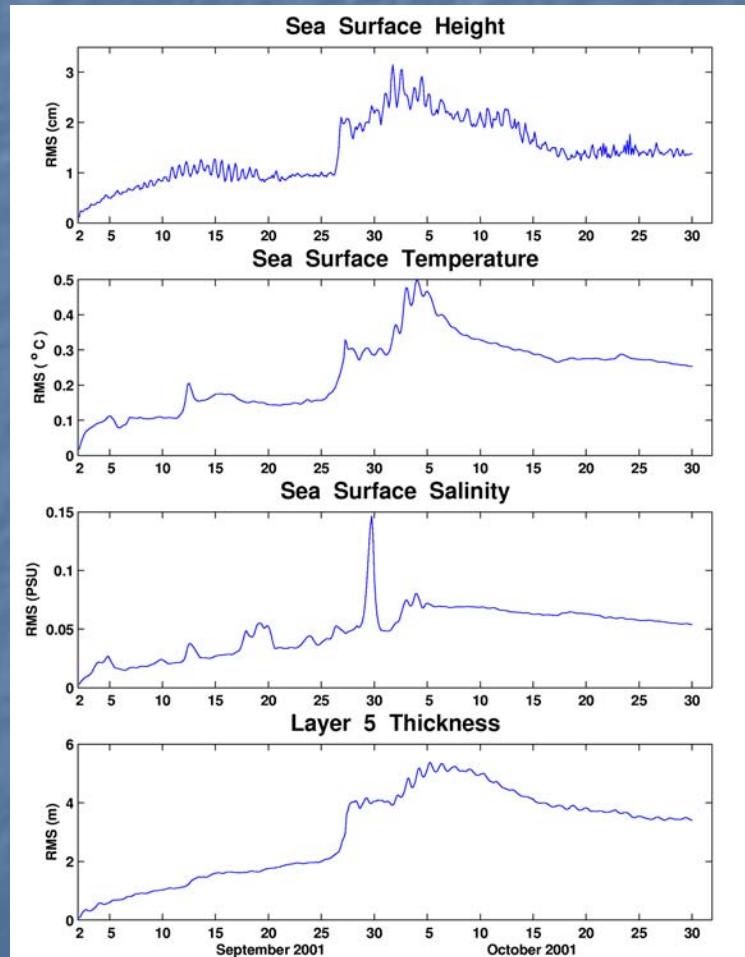
Snapshot on April 12

Starting Point

Barotropic BCS are updated every 1-day
Baroclinic BCS are updated every 6-day
10 grid-point wide relaxation zone
1-10 day relaxation e-folding time



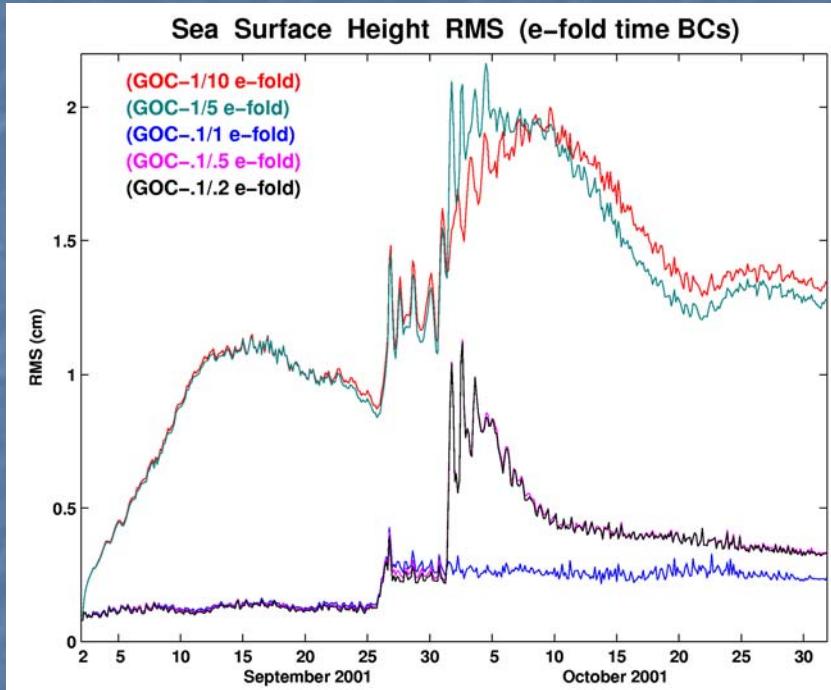
RMS error map (wrt Pacific model over GoC domain)



Time series of domain-wide RMS error

Sensitivity to:

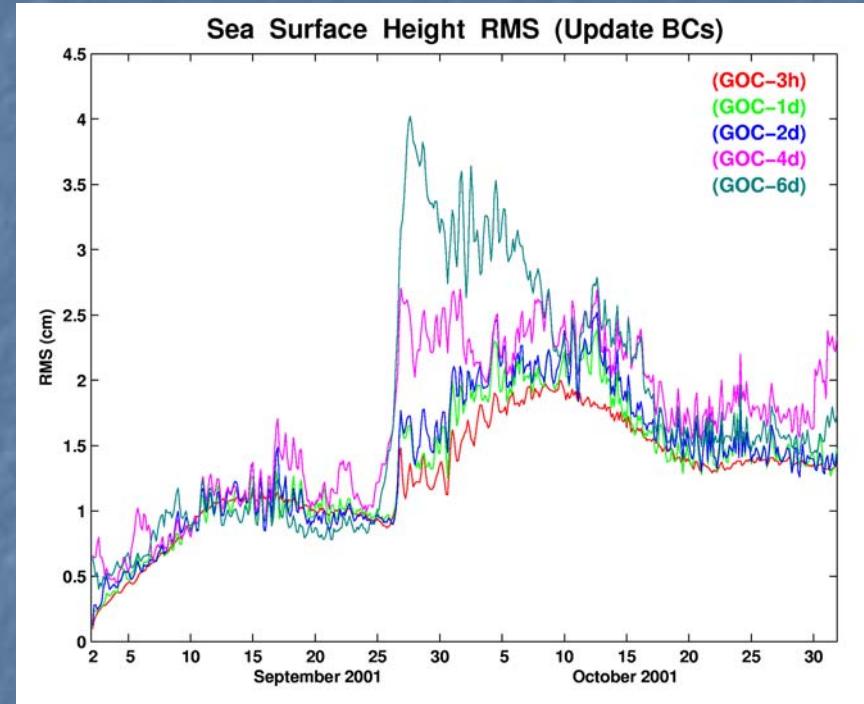
E-folding time in BZ



1-10, 1-5, **.1-1**, .1-.5, .1-.2

10 grid-point
3 hours
Barotropic + baroclinic

Updating frequency

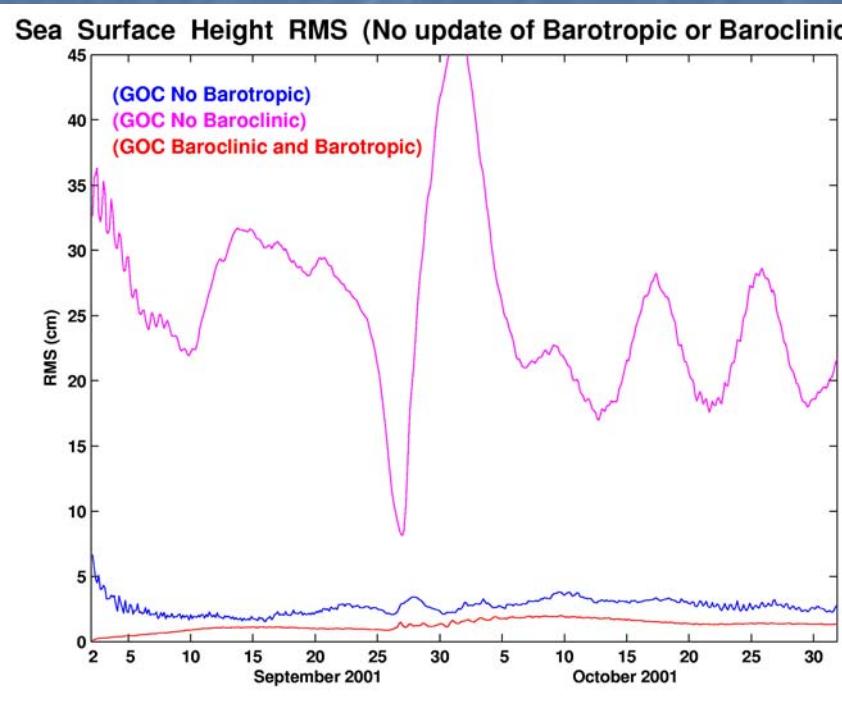


3 hours, 1, 2, 4, 6 days

10 grid-point
1-10 e-folding
Barotropic + baroclinic

Sensitivity to:

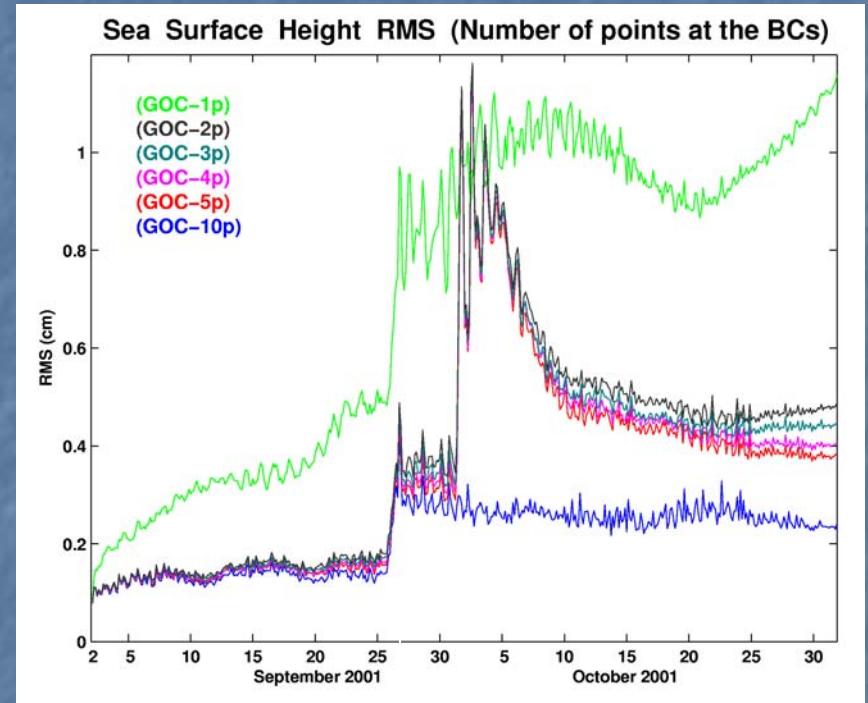
Barotropic/baroclinic mode



Barotropic or baroclinic only

10 gridpoints
0.1-1.0 e-folding
3 hourly

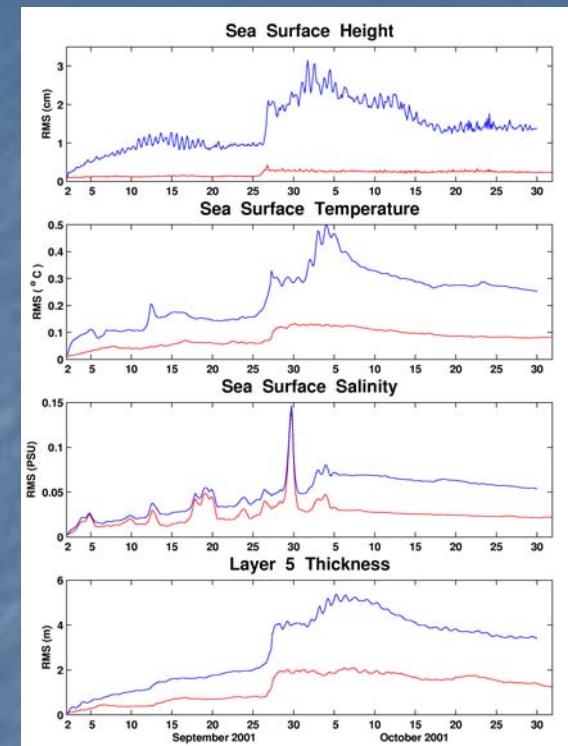
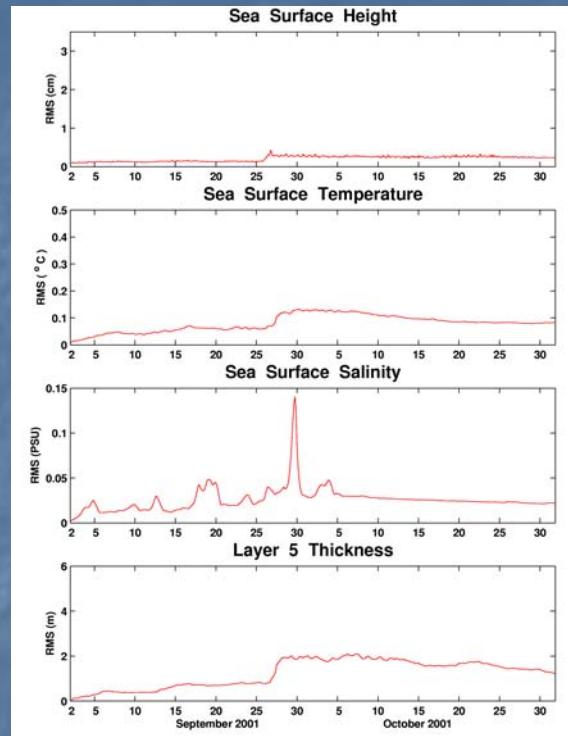
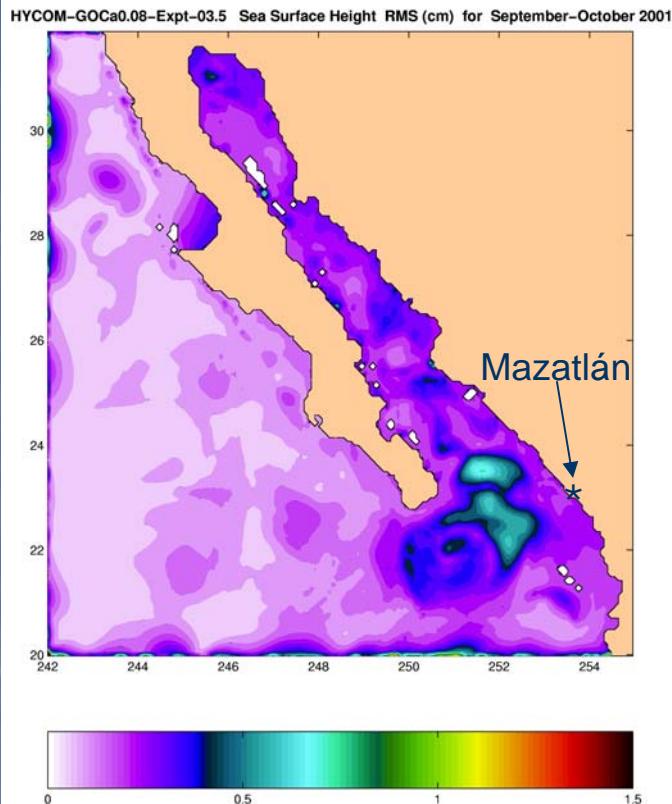
Width of buffer zone



1,2,3,4,5,10 grid-point

3 hourly
0.1-1.0 e-folding
Barotropic + baroclinic

Lowest Error Nesting Parameters



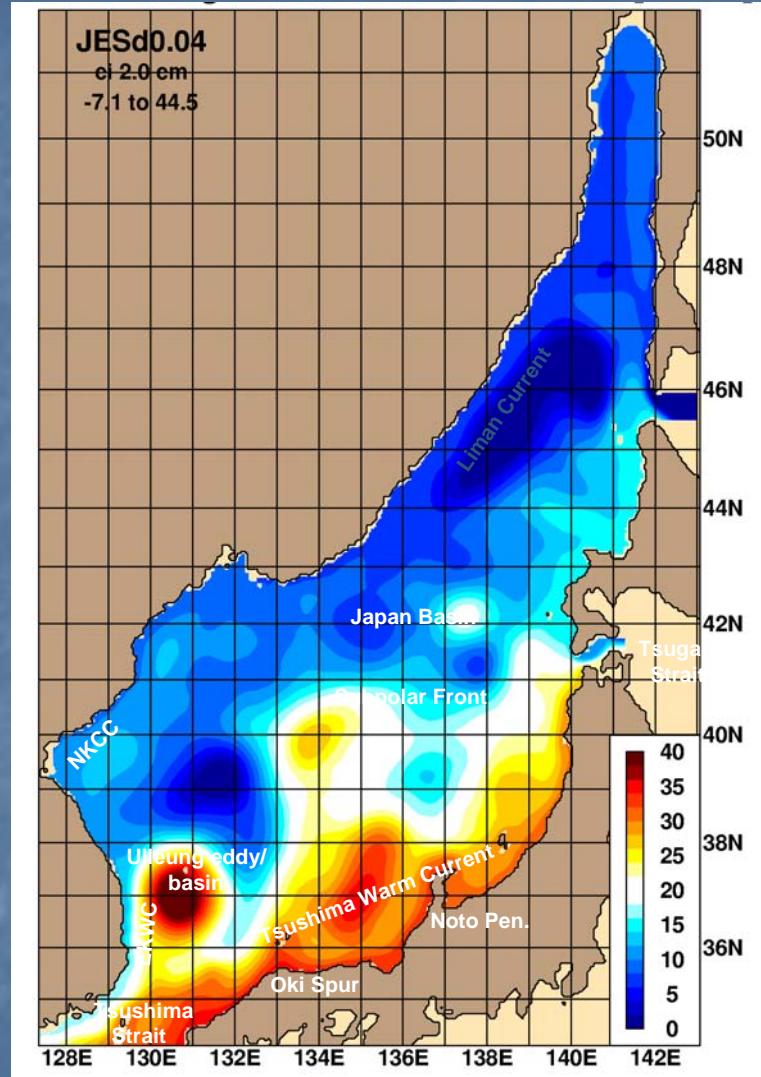
Time series of domain-wide RMS error

10 grid points
.1-1 day e-folding
3 hour updating
Baroclinic+barotropic



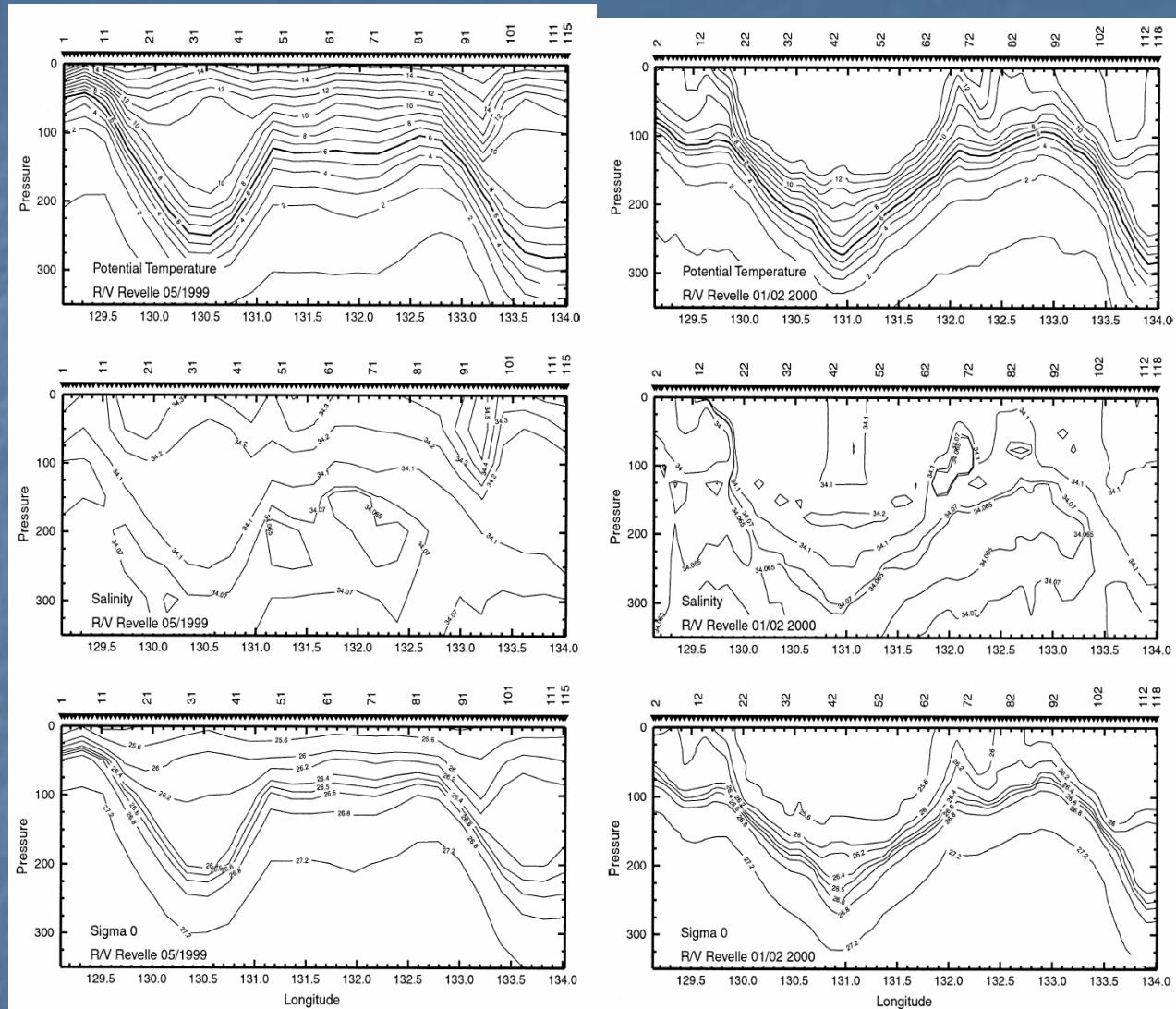
15 layer 1/25° Japan/East Sea HYCOM

Mean Sea Surface Height



2 Sverdrup barotropic straits forcing
Relaxation to climatology for baroclinic part

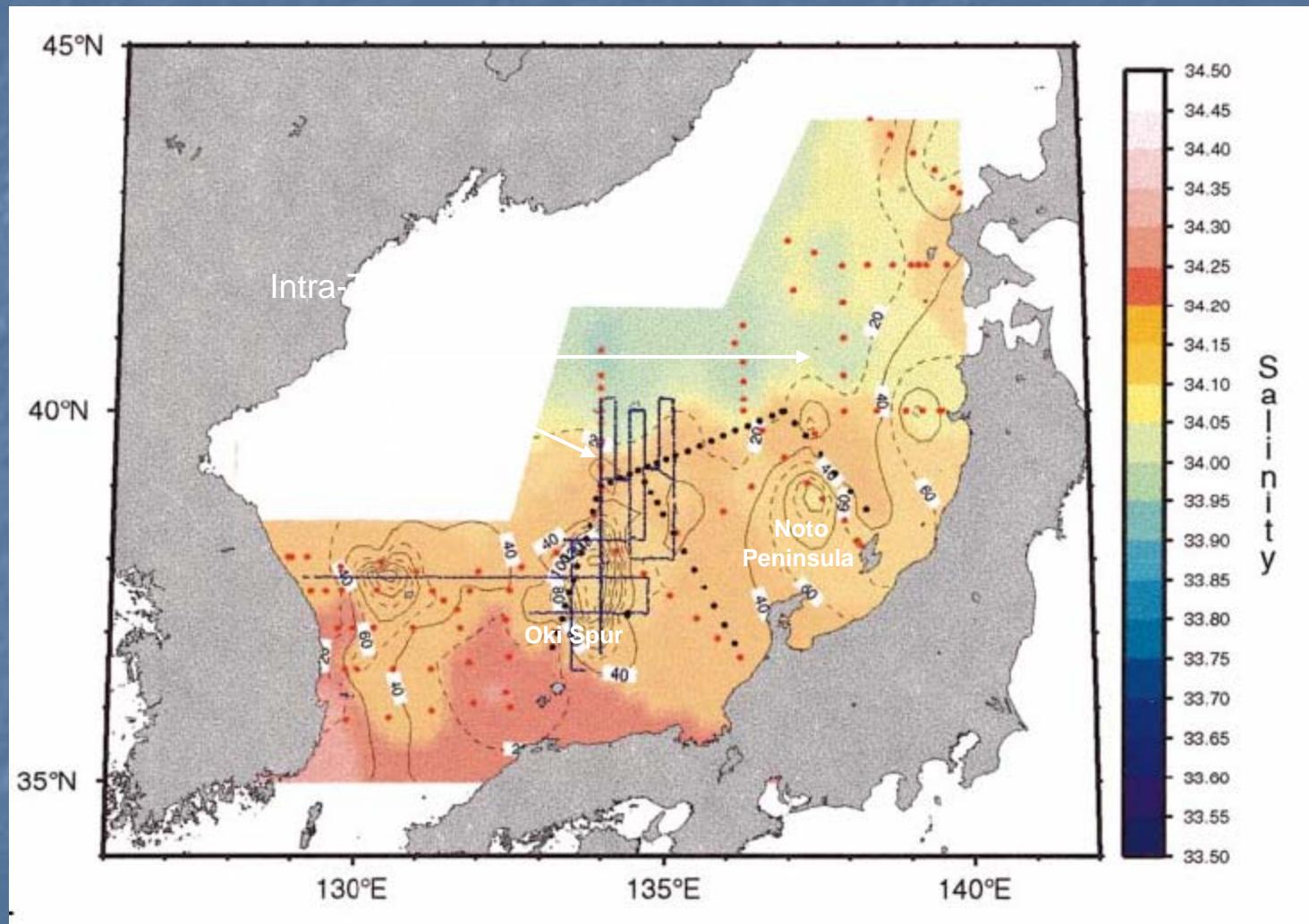
Observed JES Intrathermocline Eddies (Gordon et al., 2002)



May 1999

January 2000

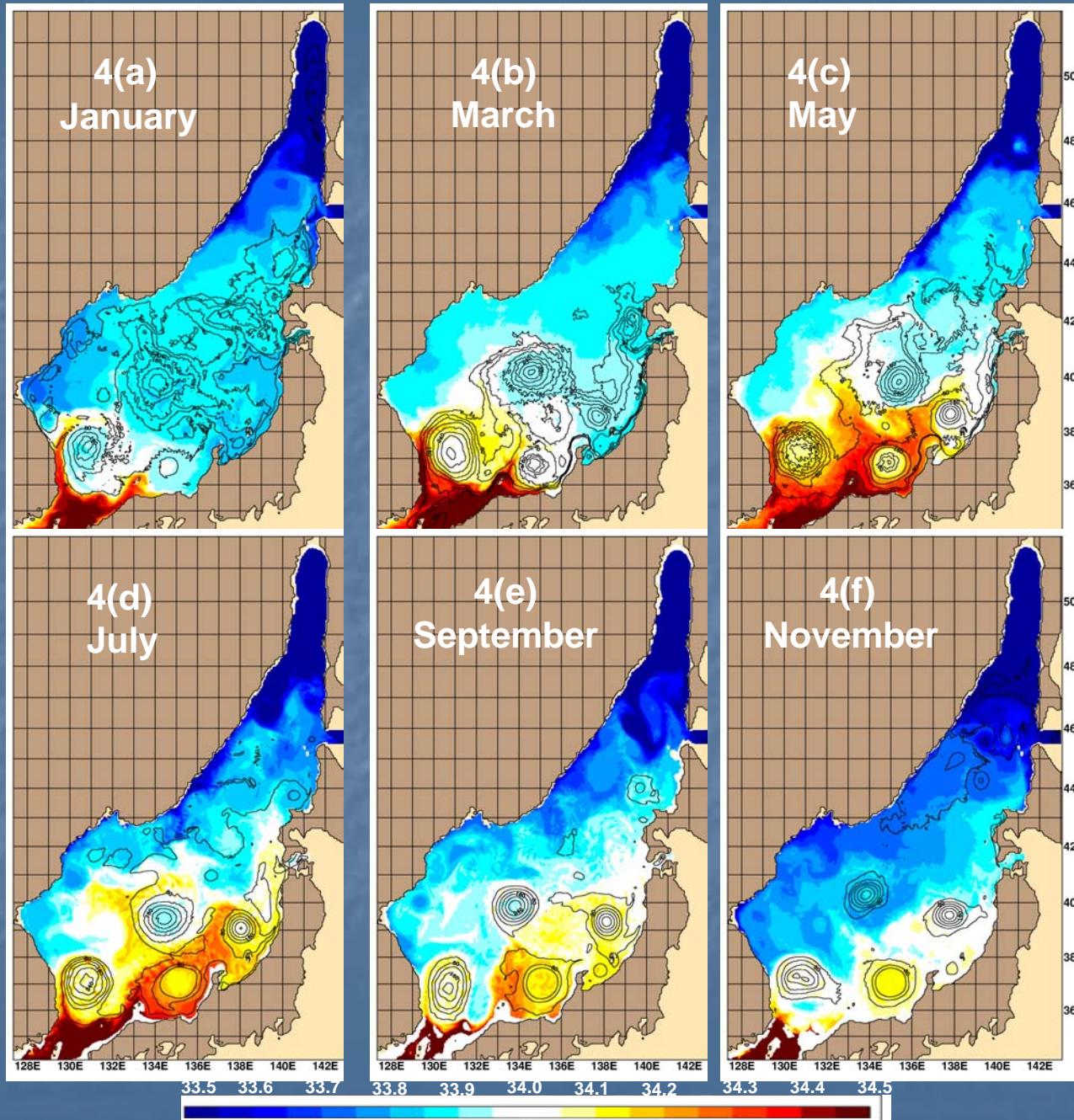
Location of JES Intrathermocline Eddies (Gordon et al., 2002)

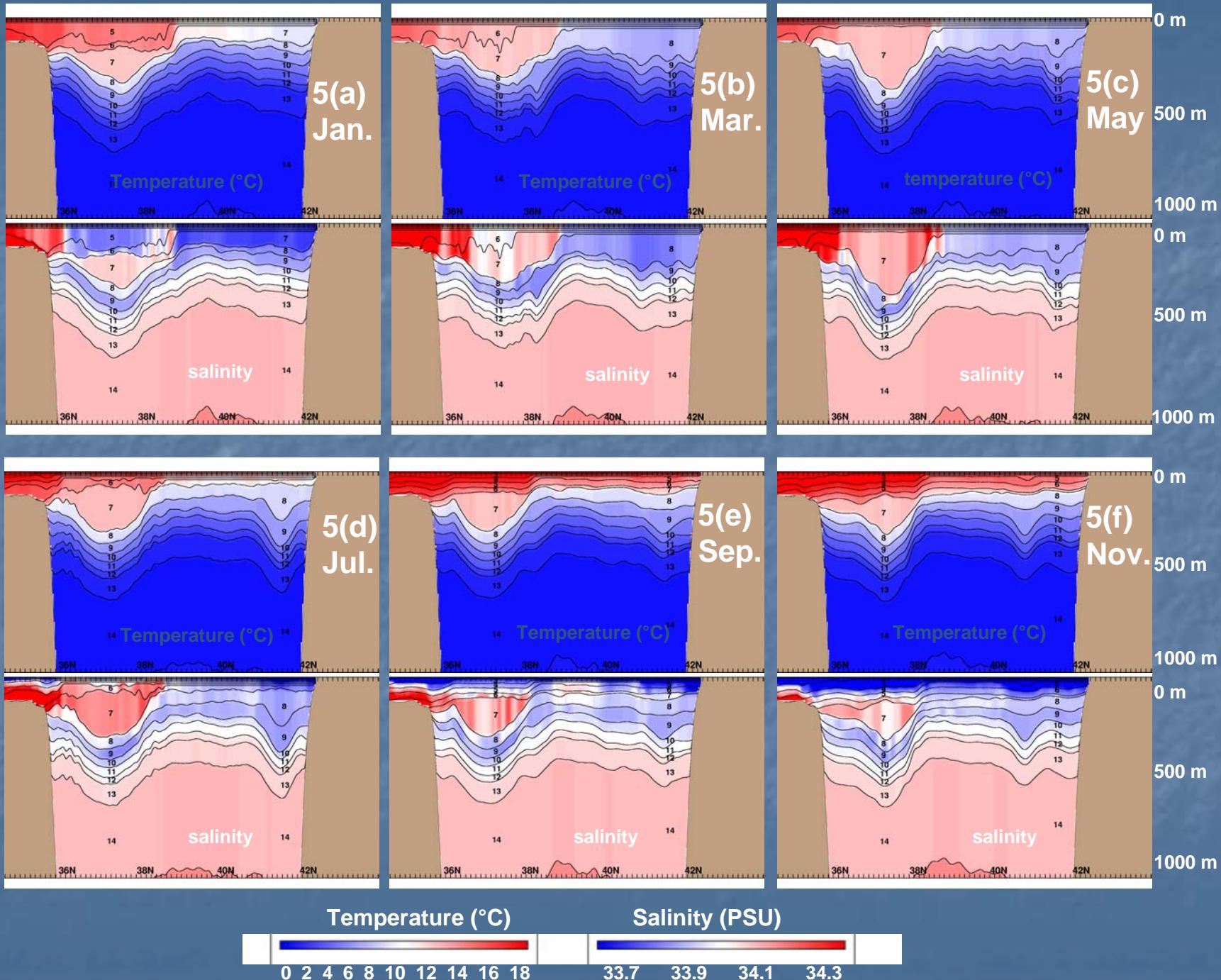


Layer thickness between the 8° - 11° isotherm



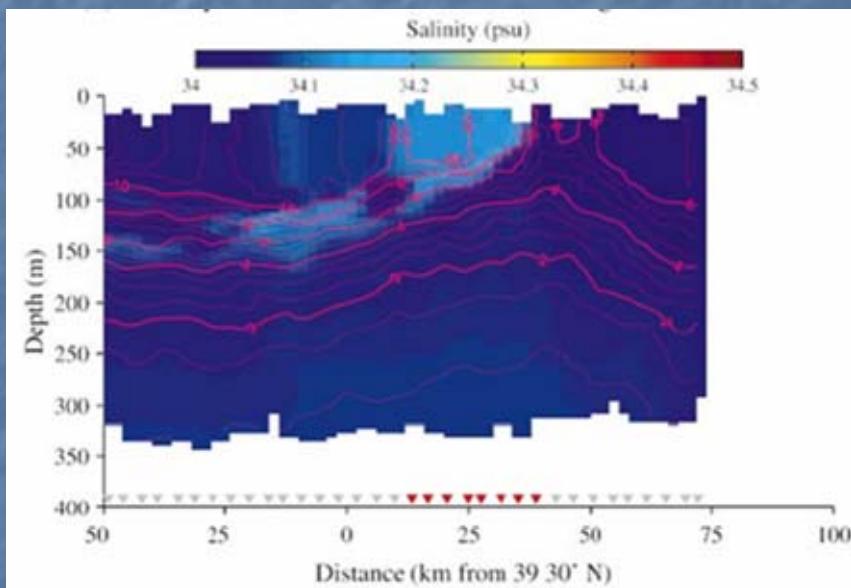
Layer 6 salinity (color) and layer 7 thickness



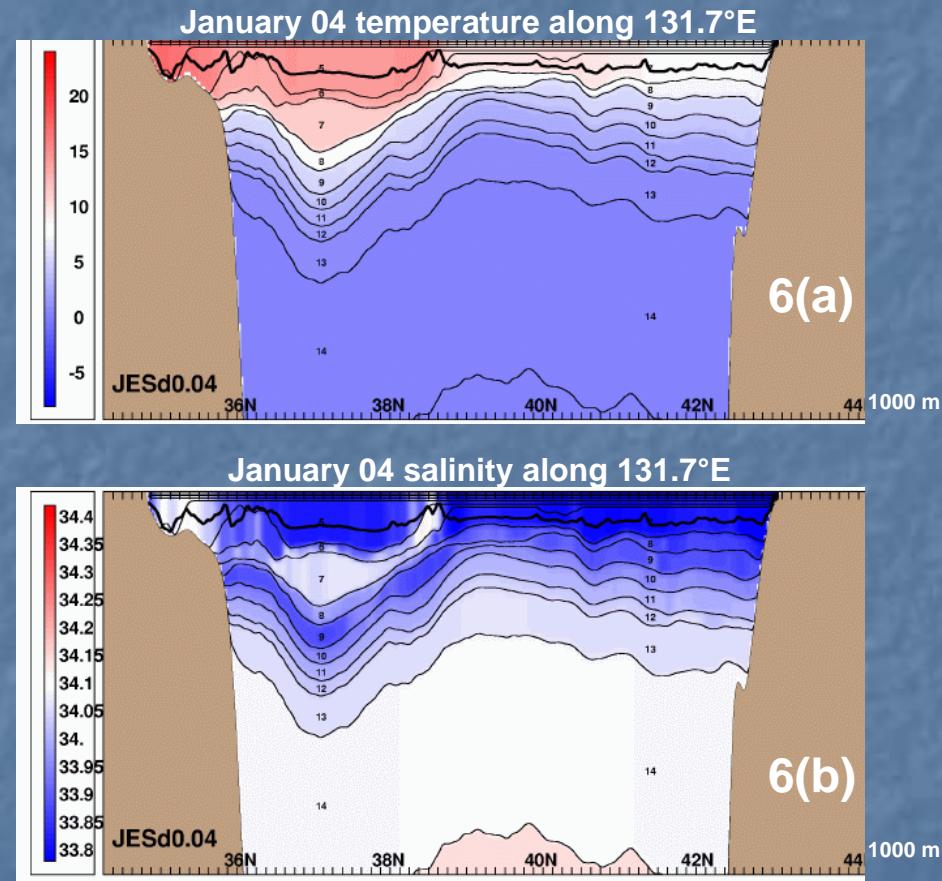




Secondary JES ITE Formation Mechanism: Frontal subduction along the subpolar front



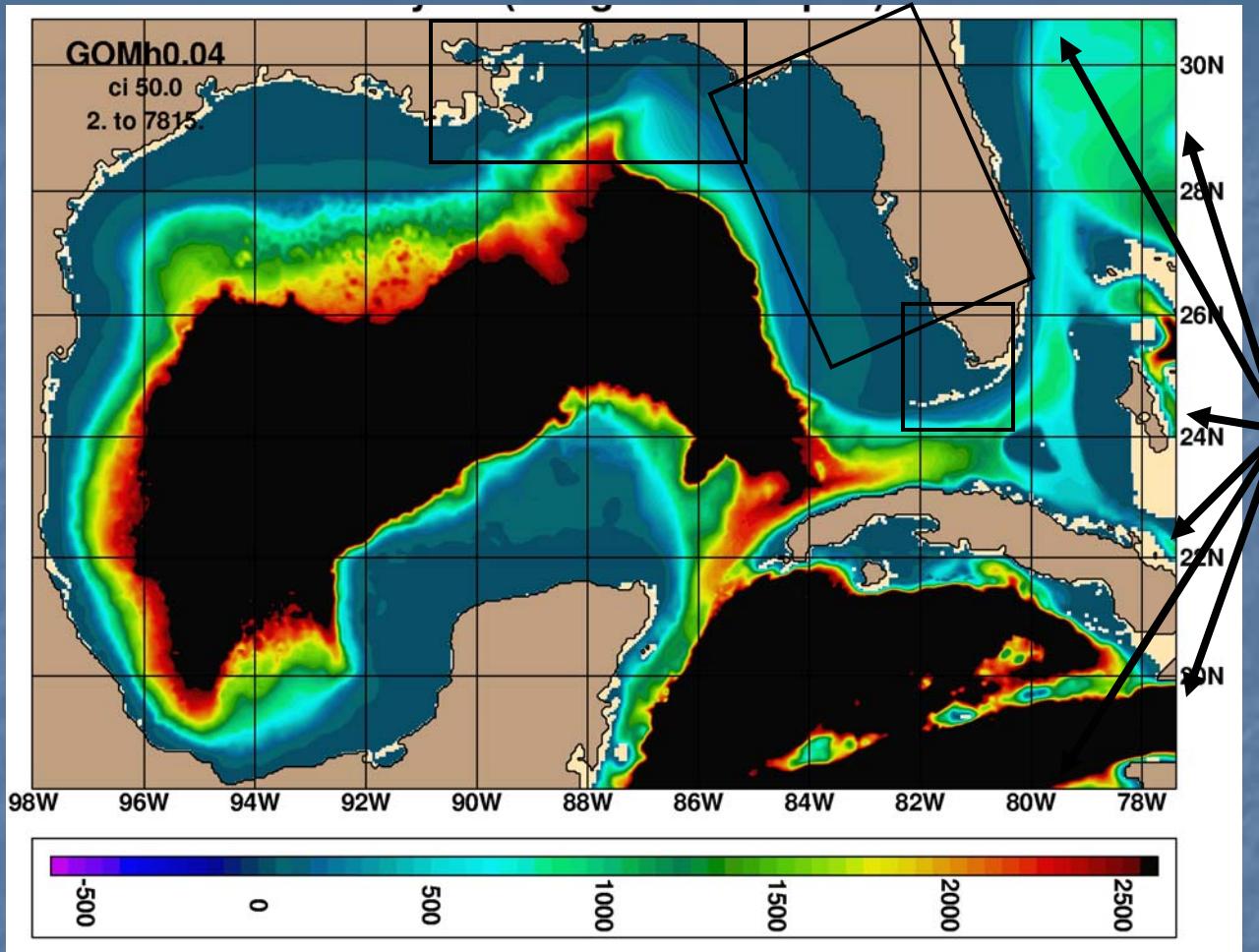
From Gordon et al. (2002)



1/25° JES HYCOM

Hogan and Hurlburt (2006)

20 layer 1/25° Gulf of Mexico Model (~4 km)



**Method of Characteristics used
To update the barotropic mode**

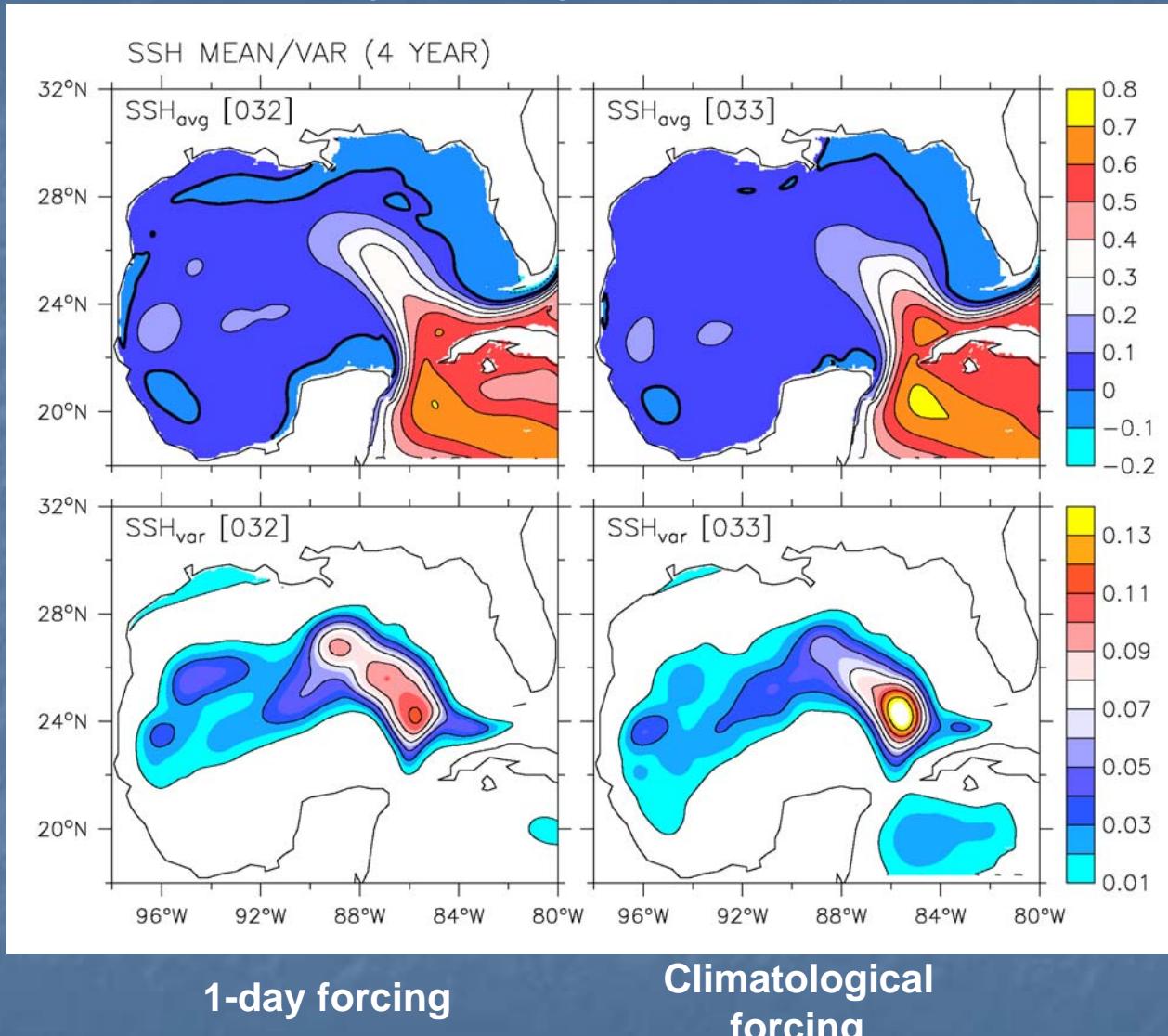
Bathy from NRL-DBDB2

**20 gridpoint buffer zone for baroclinic
mode with e-folding time .1 to 10 days**

Atlantic boundary data provided daily

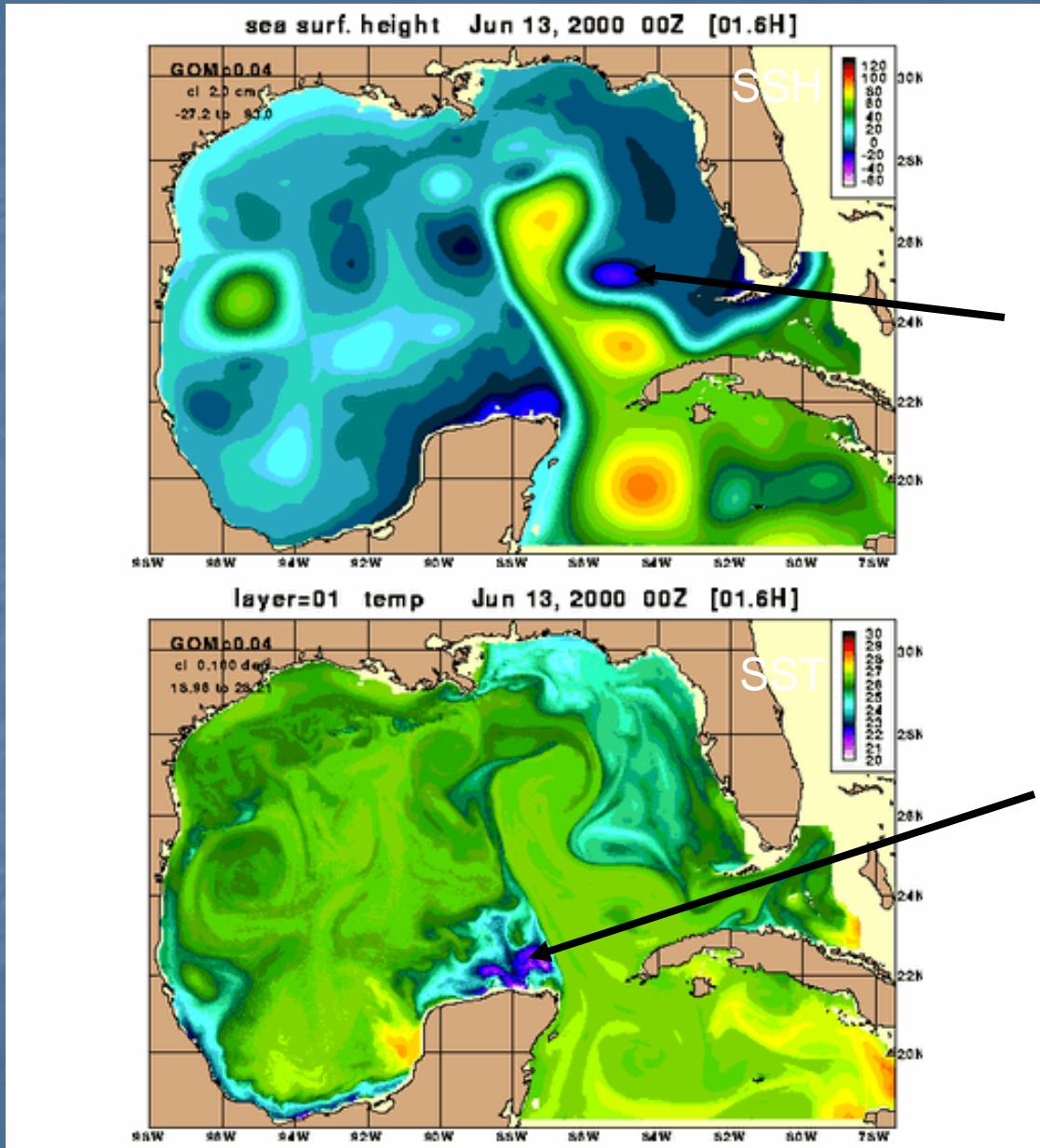
Sensitivity of boundary forcing updating

Allows for long-term integrations over any timeframe



Monthly climatology formed from 1-day archives

1/25° (~4 km) Nested Gulf of Mexico

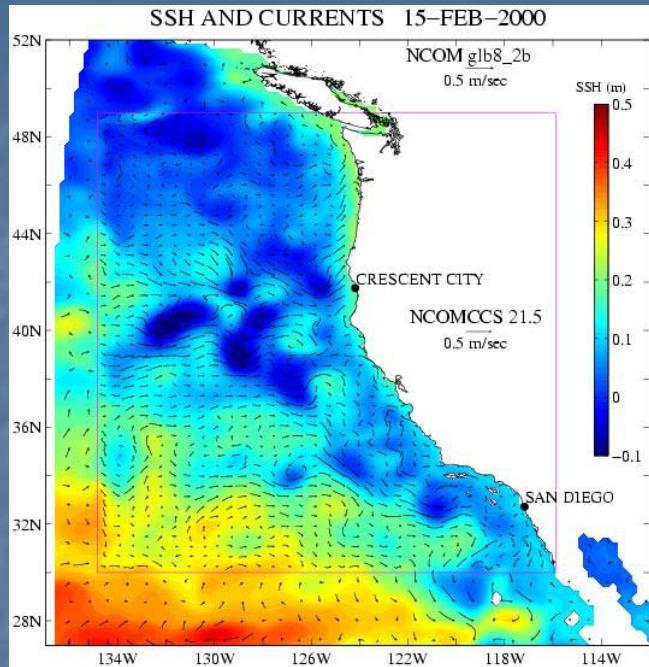


Snapshot of SSH
and SST on June, 13
2000

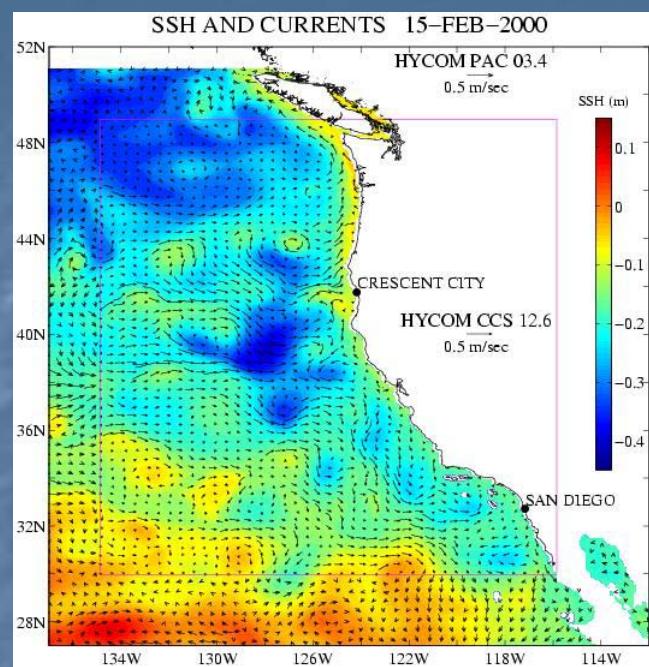
Lots of cyclonic
cold core eddies
(impact of 2x res.)

Local upwelling

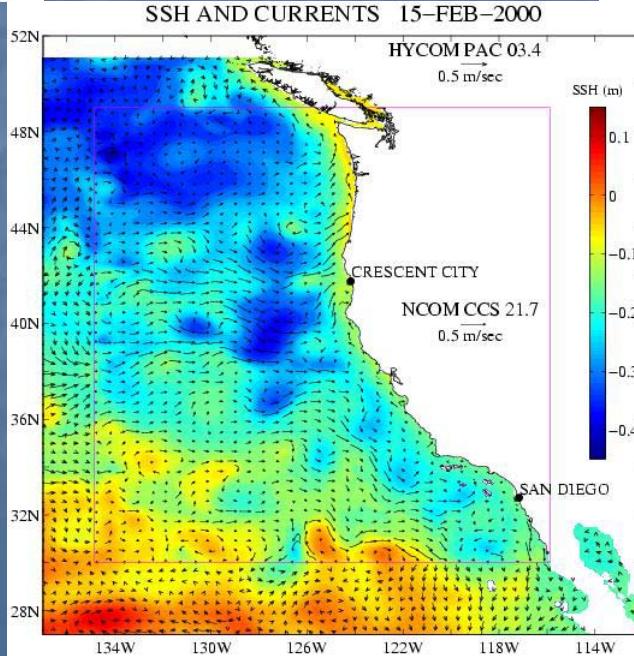
Vertical Remapping and Nesting Different Ocean Models



PAC HYCOM
to
CCS NCOM
 $(\sigma\text{-}z\text{-}\rho)$ to $(\sigma\text{-}z)$
 $1/12^\circ\text{-}1/12^\circ$

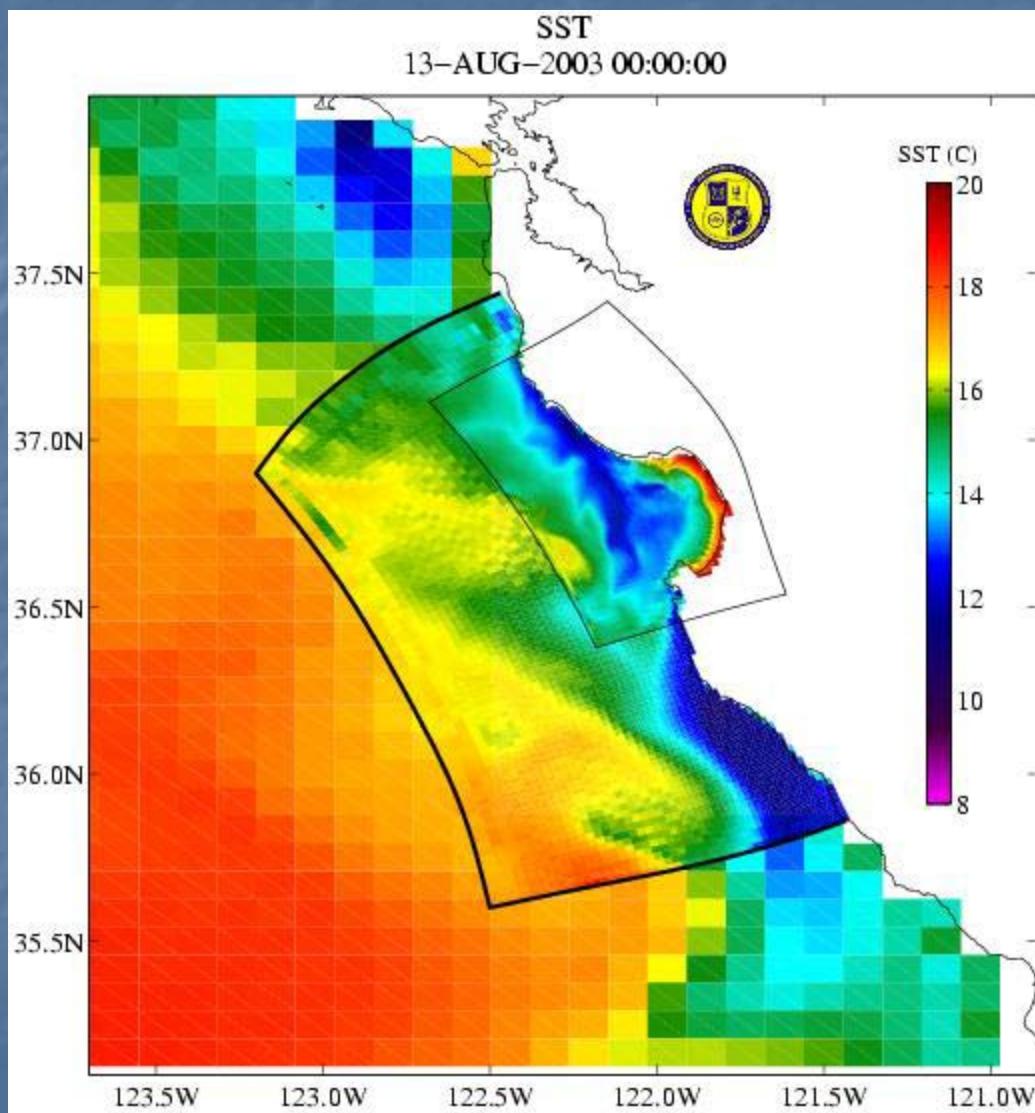


Global NCOM
to
CCS NCOM
 $(\sigma\text{-}z)$ to $(\sigma\text{-}z)$
 $1/8^\circ\text{-}1/12^\circ$



PAC HYCOM
to
CCS HYCOM
 $(\sigma\text{-}z\text{-}\rho)$ to $(\sigma\text{-}z\text{-}\rho)$
 $1/12^\circ\text{-}1/12^\circ$

Triple nesting in the California Current System



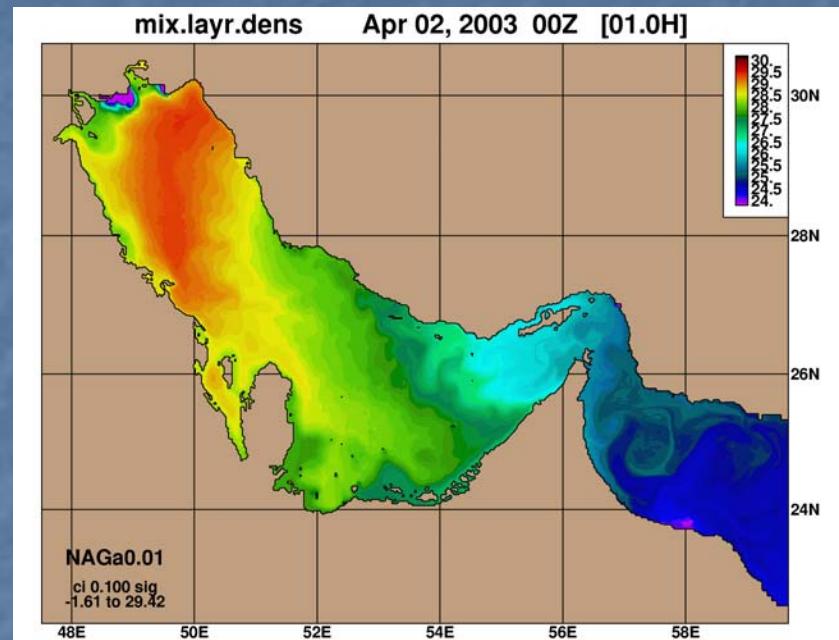
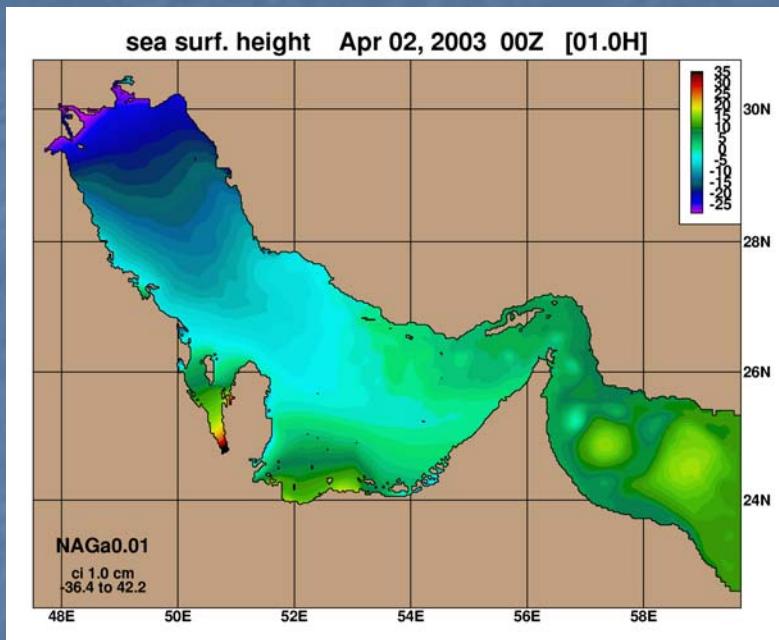
NCOM CCS 9 km

NCOM-NCOM 1-4 km

NCOM-NCOM 0.5-1.5 km



1 km Persian Gulf HYCOM



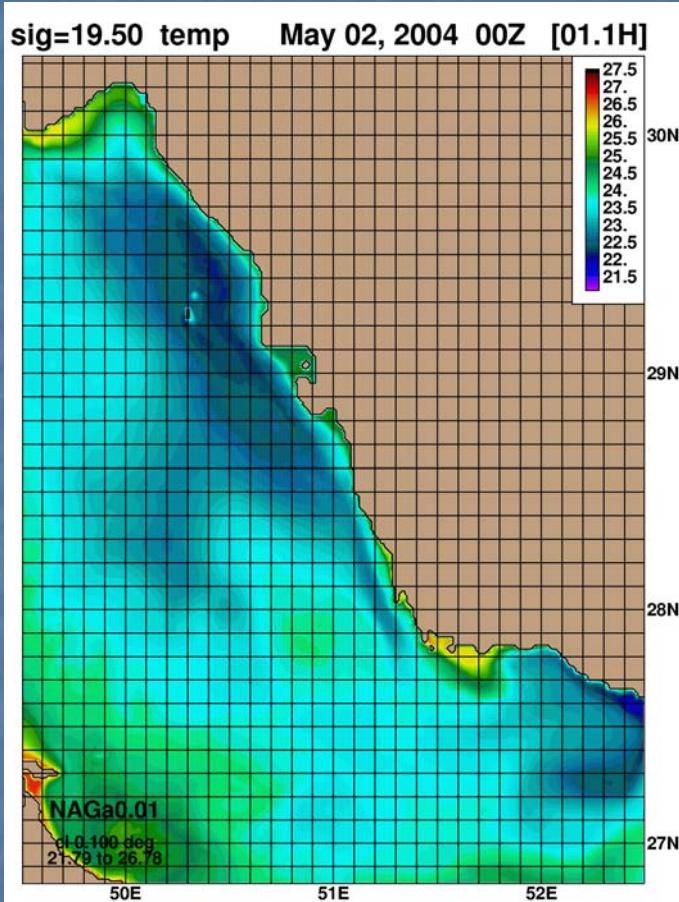
- Boundary conditions from 1/12° Global HYCOM
- Includes rivers, bottom boundary layer
- Requires remapping from σ_{2000} to σ_θ

unclassified

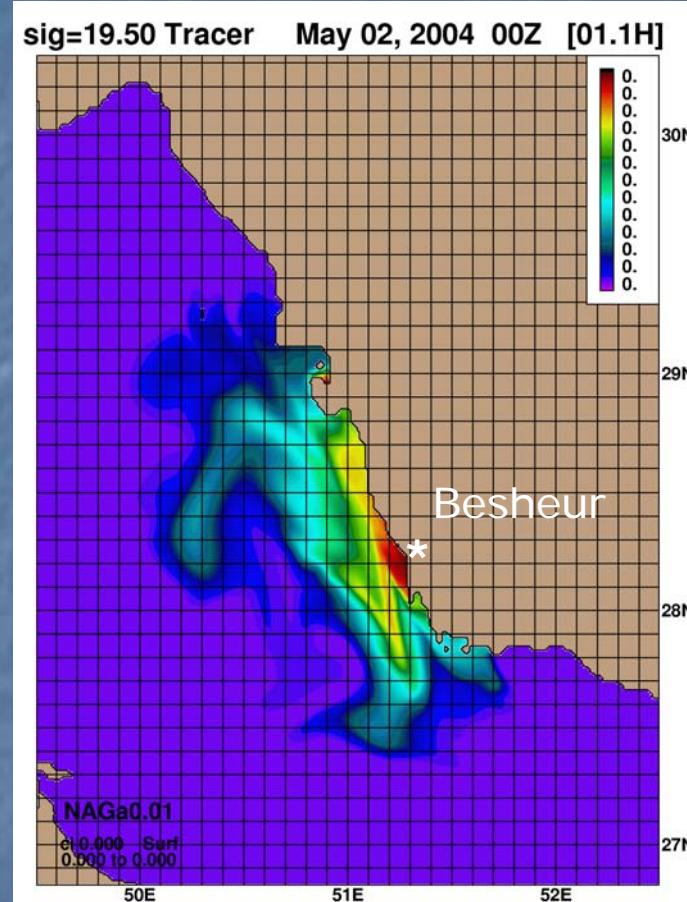


1 km Persian Gulf HYCOM

Surface Temperature



Surface Tracer



Forced with 0.5° NOGAPS and lateral boundary conditions from 1/12° Global HYCOM

unclassified



Summary and Future Plans

- A Robust capability exists for nesting HYCOM within HYCOM and HYCOM within NCOM
- Sensitivity studies reveal the most accurate nesting params
- HYCOM successfully simulates JES Intrathermocline eddies
- HYCOM successfully simulates Loop Current eddy shedding

Future Plans

- Add wetting and drying (inundation) capability to HYCOM
- Add tidal forcing to standard version
- Improve river plume dynamics
- More quantitative HYCOM-NCOM-Observations comparisons
- Evaluation of nested boundary placement (on or off-shelf)
- Implementation and evaluation of other boundary conditions
- Additional evaluation of coastal HYCOM

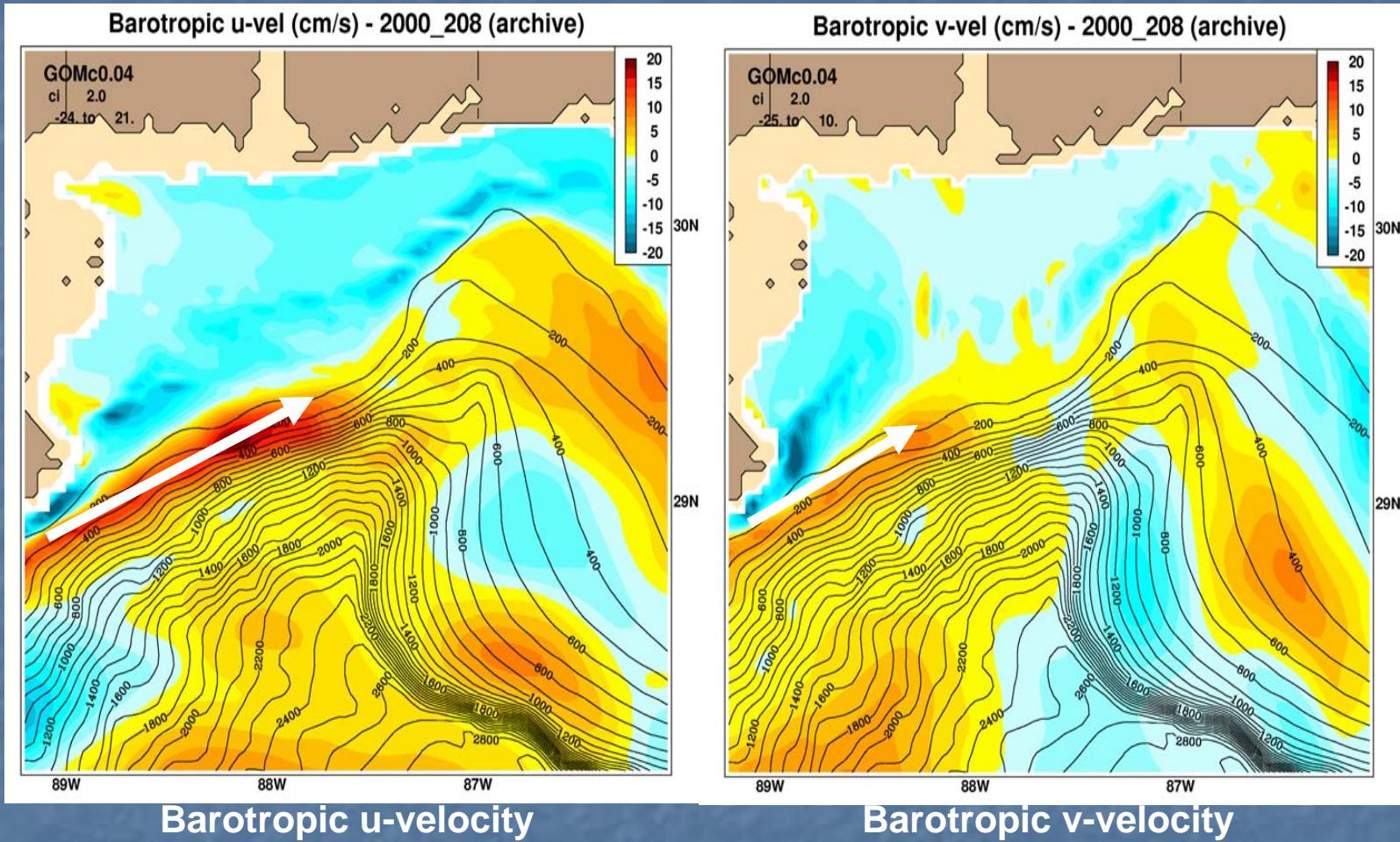
Supplemental Slides Follow

1/25° Nested Gulf of Mexico HYCOM

red=east blue=west

July 27, 2000

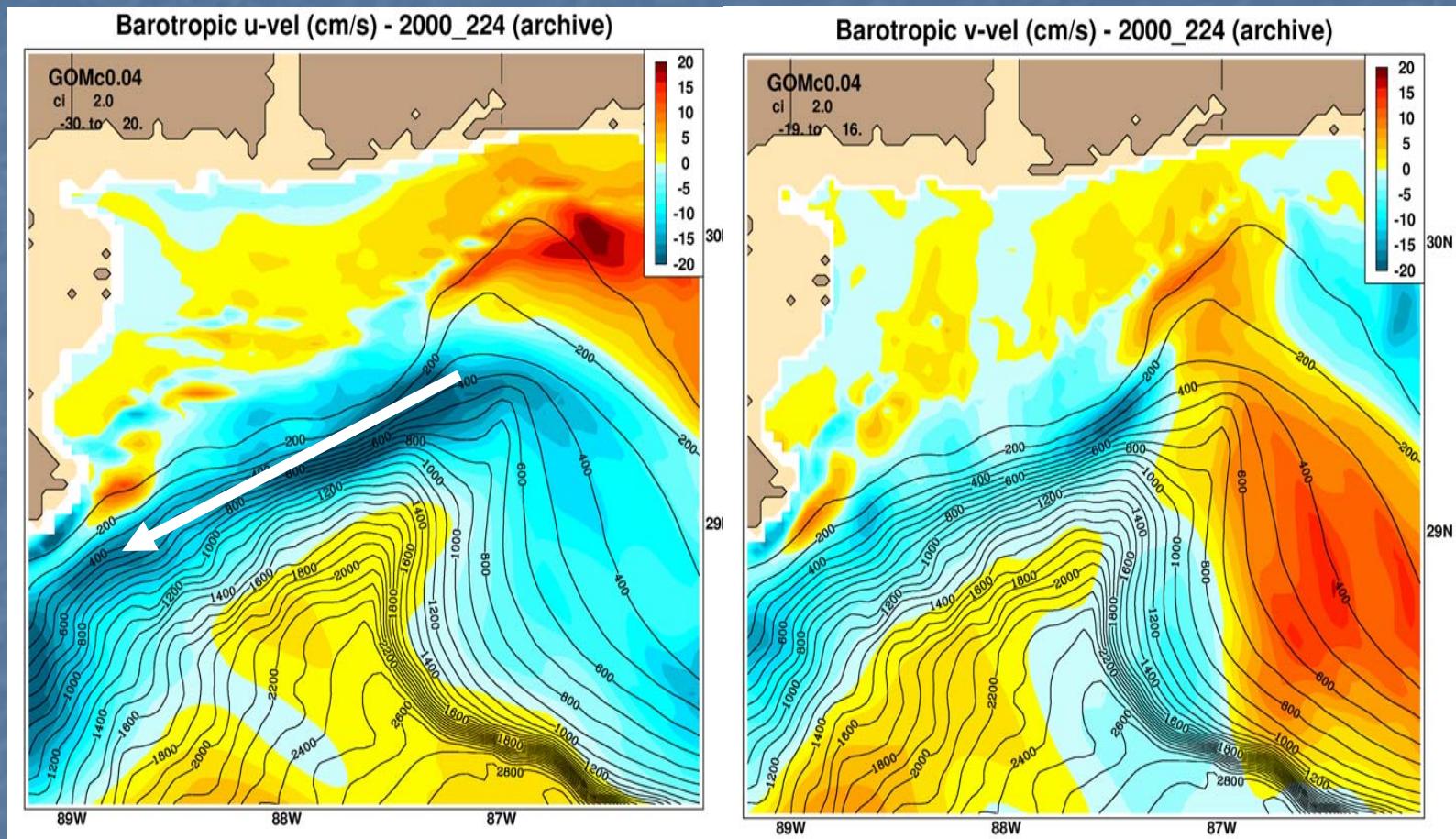
red=north blue=south



Initial eastward along-shelf break current
in geostrophic balance

1/25° Nested Gulf of Mexico HYCOM

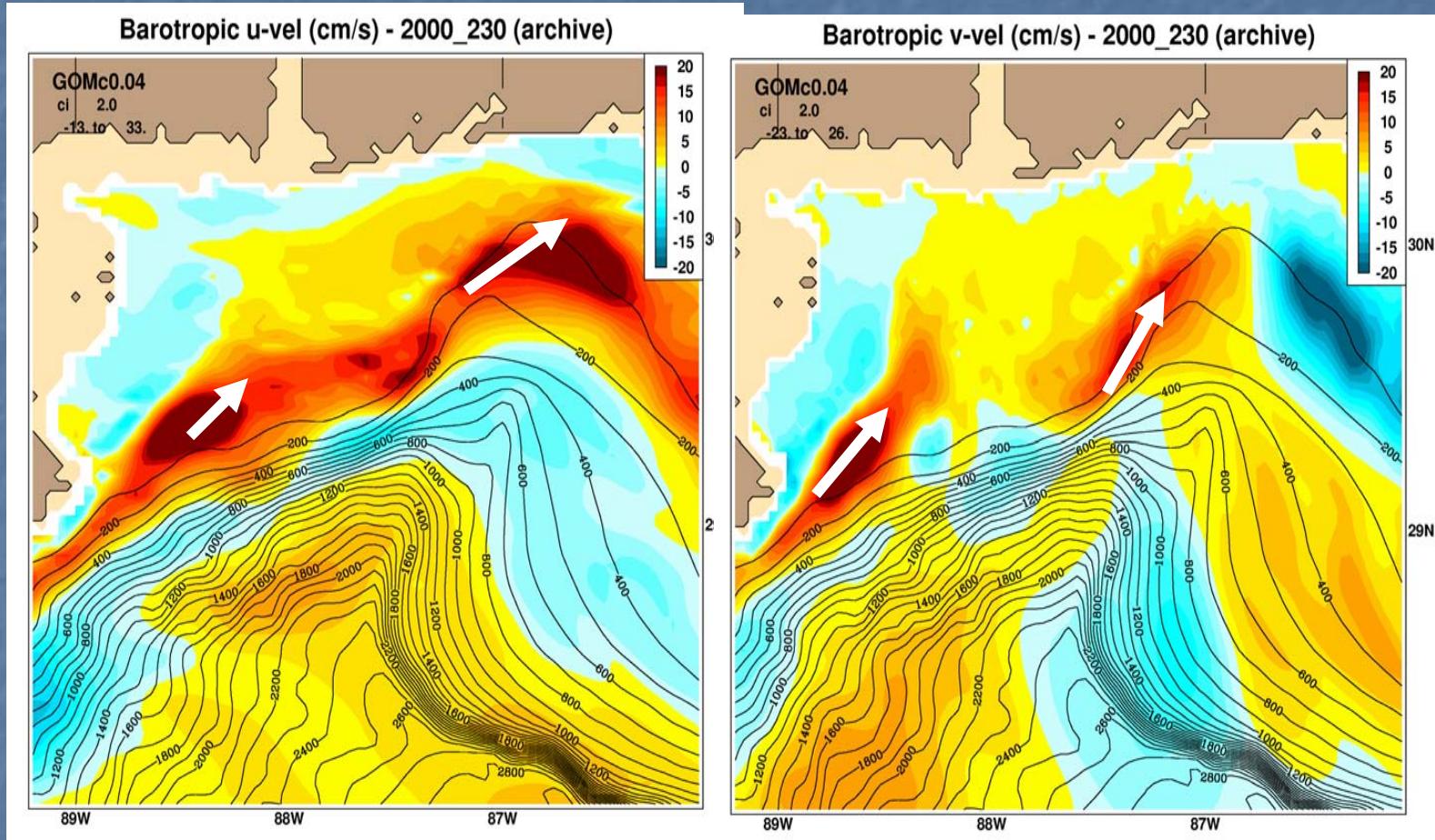
red=east blue=west August 12, 2000 (+ ~2 weeks) red=north blue=south



A reversal in the barotropic currents triggers a transition of the along-shelf break currents to flow onto the shelf

1/25° Nested Gulf of Mexico HYCOM

August 18, 2004 (+ ~1 week)



Significant cross-shelf flow exists after the reversal